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The slide has a blue header bar at the top. Below the header, the word "Agenda" is written in a large, dark blue, sans-serif font. Underneath the title is a bulleted list of five items: "• About BKF", "• Why Rehabilitation", "• Project Scoping", "• AWWA Structural Lining Classifications", and "• Rehabilitation Methods". Below the list, the text "Ask questions as we go!" is written in a dark blue, sans-serif font. In the bottom right corner, there is a small BKF logo.

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About us

480+
Employees

Founded
1915

18
West Coast Offices

160+
Professional
Engineers & Surveyors

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Services

- Civil Engineering
- Surveying
- Planning
- Transportation
- Water Resources
- Sustainability
- Utility Locating

Office Locations

| | | | |
|---------------|---------------|--------------|-----------------|
| Fresno | Santa Rosa | San Jose | Salinas |
| Modesto | Sacramento | San Rafael | San Diego |
| Newport Beach | San Francisco | Redwood City | San Luis Obispo |
| Oakland | Walnut Creek | Riverside | Pleasanton |
| | | Roseville | Portland, OR |

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Business Sectors



Transportation



Water Resources



Land Development



Land Surveying



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Water Resources

- Water Storage Tanks and Reservoirs
- Potable / Recycled Water Pipelines
- Wastewater Pipelines / Force Mains / Interceptor
- Pump and Lift Stations
- Storm Drains / Master Plan of Drainage
- Green Stormwater Infrastructure
- Sea Level Rise Resiliency
- Levee Design and Certification
- Large Trash Capture Devices
- Outfall Repairs / Rehabilitation
- Flood Control Facilities
- Creek / Stream Improvements and Restorations
- FEMA Floodplain Map Revisions
- Low-Impact Development (LID)
- SWPPP QSP/QSD

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Why Rehabilitation



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Limiting Disturbance



Stevens Creek Blvd (sjwater.com)



Stevens Creek Blvd (sjwater.com)

Heavy traffic, working hours shifted to 6 AM to 3:30 PM, retail store presence



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Lack of Access



Elm Park WM, Monte Sereno



Elm Park WM, Monte Sereno

20" pipeline, private property, established vegetation

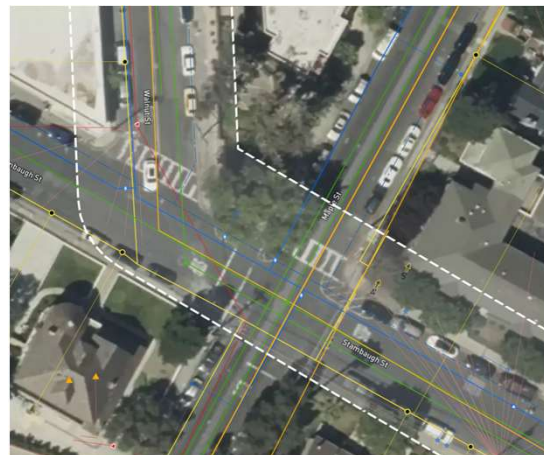


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Utility Congestion



Redwood City Sewer Capacity Improvements (Civil Grid)



Redwood City Sewer Capacity Improvements (Civil Grid)

Finding room for a separate 36" sewer line may be challenging...



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Save Time / Money



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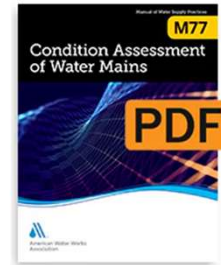
Project Scoping

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Project Scoping

Key Considerations

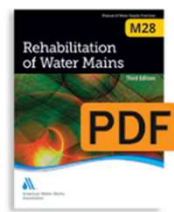
- Condition assessment challenging; no access
 - See AWWA M77 for info
- “Trenchless” does not mean “no excavation”
- Materials / products / equipment are often not cheap
- Rehab programs can help realize economies of scale
- Mixing / matching methods can yield best value
- Use bid alternatives for comparable methods
- Standardize a method or evaluate case-by-case?



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Project Scoping

- Project-Specific Evaluation Criteria
 - Structural deficiencies
 - Design life
 - Site constraints and obstructions
 - System pressures
 - Hydraulic capacity
 - According to AWWA M28



<https://www.amesburyma.gov/ImageRepository/Document?documentId=468>

Table 1-1 Hazen-Williams roughness coefficient

| Condition | C |
|---|---------|
| New pipe | 130–140 |
| Fair to normal (interior clean) | 100 |
| Significant reduction in pipe capacity | 70 |
| Severe problem—interior cross section greatly reduced | 30–50 |

$$V = K C^{0.63} S^{0.54} \quad \leftarrow \text{Hazen-Williams Equation}$$



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Project Scoping

Pipe Condition

- Is pipeline suffering from internal or external corrosion?
- Can we rely on host pipe?
- Does host pipe have holes? How big?

Hydraulics

- Can pipe diameter be reduced?
- Does diameter need to be increased?
- What system pressures are required?

Disturbance

- How long can pipeline be shutdown?
- How many services are on the line?
- How disruptive will excavation be?

Loading

- What dead/live loads need to be supported?

Material

- Is AC pipe involved?
- Is pipe burstable?

Bypass

- Can services/hydrants operate during installation?



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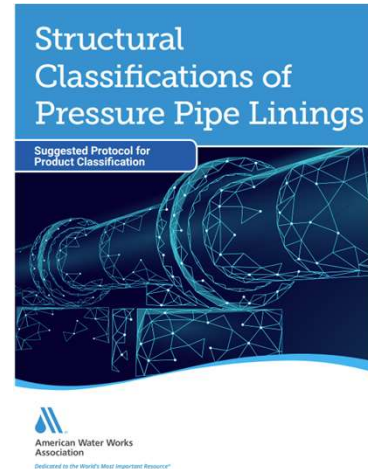
Structural Lining Classifications



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Structural Lining Classifications

- **Class I Lining**
 - Nonstructural
 - Protect inner surface of host pipe from further corrosion/tuberculation
 - Host pipe still provides all internal/external load resistance
- **Class II and III**
 - Semi-structural systems
 - Can sustain internal pressure loads, but relies on host pipe for external loads
 - Can bridge holes/gaps in host pipe
 - **Class II:** depend on adhesion to host pipe to prevent collapse
 - **Class III:** sufficient ring stiffness to be self-supporting
- **Class IV**
 - Structurally independent equivalent to replacement pipe



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Structural Lining Classifications

| Method | Class I | Class II/III | Class IV |
|------------------------------|---------|--------------|----------|
| SIPP | X | X | |
| FFRP | | X | |
| CIPP | | X | X |
| Sliplining* | | | X |
| Pipe Bursting / CTPS* | | | X |
| MICP | | | X |
| CFRP | | | X |

**method results in installation of new pipe, not a liner*



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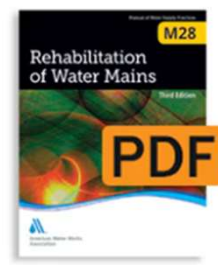
Rehabilitation Methods



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Rehabilitation Methods

- Spray-In-Place Pipe (SIPP) Linings
- **Flexible Fabric Reinforced Pipe (FFRP)**
- **Cured-In-Place Pipe (CIPP)**
- **Sliplining**
- **Pipe Bursting**
- Manufactured In Place Composite Pipe (MICP)
- Close Tolerance Pipe Slurrification (CTPS)
- Carbon Fiber Reinforced Polymer (CFRP)



Note: BKF does not endorse any products, contractors, or manufacturers



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Spray-in-Place Pipe (SIPP) Linings



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AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

SIPP

- Typically Class I, but can be Class II and III
 - Epoxy/mortar – minimal strength enhancement
 - Polyurea – multiple coats can enhance strength
- Coating that protects the host pipe
- Applied mechanically (spincaster)
- Length controlled by equipment
 - AWWA suggests around 600 to 700 feet
- Returned to service
 - 4 to 7 days for mortar
 - Same day for rapid set polymers
- Negligible hydraulic capacity reduction



Figure 6-1, AWWA M-28

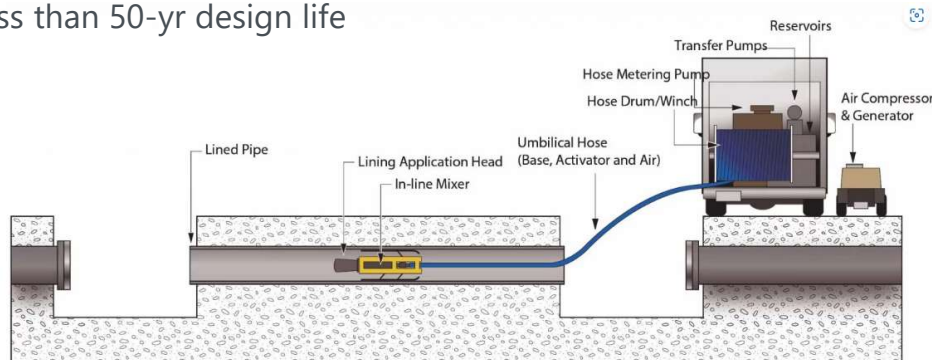


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AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

SIPP

- Need to clean/inspect pipe prior to application
- Claim to navigate 45-deg bends, but recommended to verify with mfr
- Less than 50-yr design life

Source: <https://www.sippamericas.com/sipp-lining-equipment/>

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AWWA M28, Chap. 5 and 6 / ANSI/AWWA C602 and C620

SIPP

SIPP Americas (<https://www.sippamericas.com/>)

- 2-part, non-water-sensitive polyurea (4" to 42")
- 1mm to 3.5mm in a coat; 14mm max thickness
- Can CCTV 15min after coating; 60 min return to service
–8hr re-coat window
- 360 psi short-term burst pressure for 6" pipes
–Decreases as diameter increases
- Can be designed for Class I thru Class III (and "Class III+")
- Can line up to 1,350 feet in a day; 2,600 feet in two days with 2 pits
- Trying to compete with CIPP for pipes in decent condition



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Flexible Fabric Reinforced Pipe (FFRP)

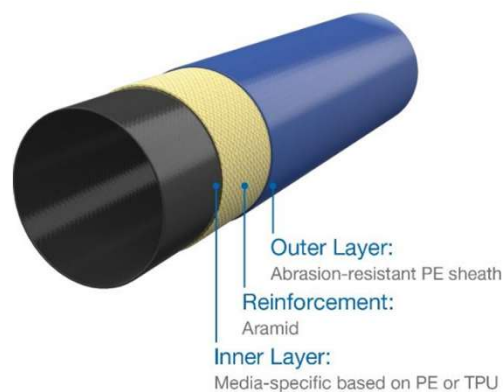


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Not In AWWA M28, ASTM F3708 for Primus

FFRP (Primus Line, Bullet Liner)

- 2 primary manufacturers
 - Bullet Liner (Asia)
 - Primus Line (Europe)
- Doesn't require curing
 - PE inner/outer layer, fabric for middle layer
- 50-yr design life
- Can't be tapped
- Excavation limited to pit at each end
 - Can be as small as approx 5'x8'
- Pulled through, inflated with air, single-day install (depending on the length)



Source: Primus Line Literature

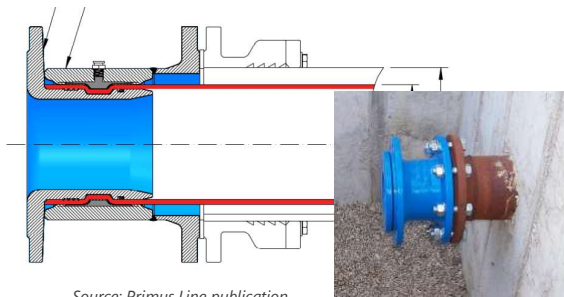


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Not In AWWA M28, ASTM F3708 for Primus

FFRP (Primus Line, Bullet Liner)

- 35-40% cheaper than CIPP
 - According to Primus rep
- All installers have to be certified to work on the liner or fittings



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Not In AWWA M28, ASTM F3708 for Primus

FFRP (Primus Line, Bullet Liner)

| Method | Bullet Liner | Primus Line |
|-----------------------------|----------------|-----------------|
| Diameters | 4" to 48" | 6" to 18" |
| Operating Pressures** | Up to 232 psi* | Up to 1,189 psi |
| Annular Space / Type of Fit | None / Close | Varies / Loose |
| Pressure De-Rating at Bends | No | Yes |

*manufacturer says they can make custom liners to withstand higher pressures

**depends on liner size/type (not every liner size can withstand max pressures shown here)

Other Considerations:

- Kevlar vs no Kevlar and how many layers
- 3rd party testing available or not
- NSF 61 certification of liner/fittings for the materials used
- ASTM F3708 for Primus / loose-fit



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Cured-In-Place Pipe (CIPP)



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AWWA M28, Chap 7 / ASTM F1216

CIPP

- Glass-reinforced felt lining inverted into host pipe and cured
- Class IV – fully structural solution
 - Class III using “partially deteriorated condition”
- Diameters: 4” to 108”
- Negligible capacity reduction
 - Rule of thumb: (dia in inches) / 2 = mm
- Max operating pressure = 250 psi
- Pit sizes similar to FFRP



<https://trenchlesstechnology.com/aegion-corp-continues-focus-trenchless-technology/>



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CIPP

- 50-yr design life
- **Can** be tapped
- 2 to 6 hr cure time (average)
 - Hot water cure
- Valves and tees/crosses need to be removed
 - Usually place pits at these locations
- Can restore services robotically
- Historically, service taps have been weak points, but technology is always evolving



<https://trenchlesstechnology.com/aegion-corp-continues-focus-trenchless-technology/>



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Sliplining



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Sliplining

- Pulling smaller pipe into host pipe
 - Grouting annular space
- Typically install PVC or HDPE with limited disruption
- Requires capacity reduction
- Can't pull through bends, valves, fittings
- Pits are usually larger for fused pipe to accommodate pipe curvature to reach depth
 - Restrained joint PVC can reduce pit sizes and pipe staging area
- Requires excavation to restore services



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Sliplining



https://www.westlakepipe.com/sites/default/files/MU-BR-002-US-EN-0522.1_Segmented-PVC-vs-HDPE.pdf

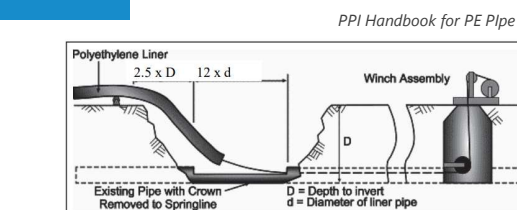


Figure 6 Typical Sliplining Access Pit for Prefused Lengths of Polyethylene Liner



<https://www.wiawwa.org/general/custom.asp?page=vendorundergroundolutions>



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Pipe Bursting



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Pipe Bursting

- Breaks old pipe; new pipe installed in same location
 - End result is new pipe
- Only method that can upsize the pipe
 - Up to about 2 pipe sizes
- Can't pull through acute bends, valves
- Pits are usually larger for fused pipe to accommodate pipe curvature to reach depth
 - Restrained joint PVC can reduce pit sizes and pipe staging area
- Requires excavation to restore services



TT Technologies



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Pipe Bursting

- Challenging materials
 - Steel should not be too thin
 - DIP not always predictable
 - Can't burst bar-wrapped, reinforced pipe
- Heave
 - Shallow cover may damage surface as soil compresses outward from pipe
 - Need (2 to 3) foot cover + (1 to 2) feet for every inch of upsize
- Pneumatic vs Static Bursting
 - Pneumatic hammer used on fracturable pipe
 - Static system used to split pipe (constant pull)
 - Pneumatic can only install HDPE; can damage other pipe
 - Static can install fusable or segmental pipe

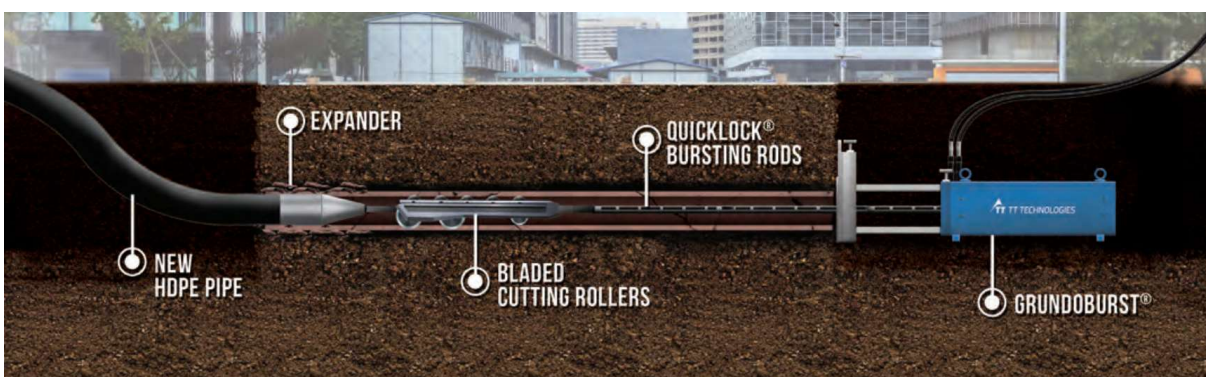


TT Technologies



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Pipe Bursting



TT Technologies

Case studies claim potential for 30% savings compared to open-cut, even digging up services



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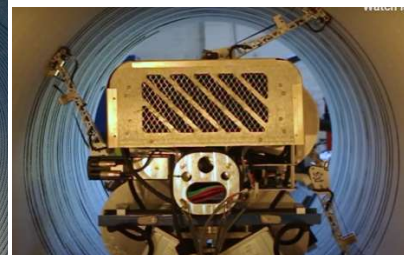
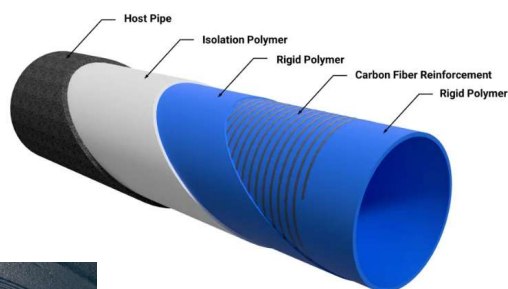
Manufactured-In-Place Composite Pipe (MICP)



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MICP

- Only one known manufacturer
–SIPP Tech
- 48" to 96"
- 250 psi and above



SIPP Tech



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Close Tolerance Pipe Slurrification (CTPS)



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CTPS

- Trenchless **removal and replacement** of AC pipe
- Reamer grinds AC pipe into slurry that gets pumped out while pulling in new pipe
- Relatively new concept
 - EPA-approved in 2019
- Limited contractor pool
- Only being marketed by Azuria



26852 Federal Register / Vol. 84, No. 111/Monday, June 10, 2019/Notices

stringent as the NPDES at 40 CFR parts 141 and 142, as well as adopt all new and revised NPDES in order to retain primacy (40 CFR 142.12(a)).

B. How does this action affect Indian country (18 U.S.C. 1151) in Utah?

The EPA's approval of Utah's revised PWS program does not extend to Indian country as defined in 18 U.S.C. 1151. Indian country in Utah generally includes (1) lands within the exterior boundaries of the following Indian reservations located within Utah. In part or in full: The Goshute Reservation, the Navajo Indian Reservation, the reservation lands of the Paiute Indian Tribe of Utah (Cedar Band of Paiutes, Kanab Band of Paiutes, Koosharem Band of Paiutes, Indian Peaks Band of Paiutes and Shivwits Band of Paiutes), the Skull Valley Indian Reservation, the Utah and Ouray Reservation (subject to federal court decisions removing certain lands from Indian country status within the Utah and Ouray Reservations), and the Washakie Reservation; (2) any land held in trust by the United States for an Indian tribe; and (3) any other areas which are "Indian country" within the meaning of 18 U.S.C. 1151. The EPA's eligible Indian tribes, as appropriate, will retain PWS program responsibilities over public water systems in Indian country.

Please bring this notice to the attention of any persons known by you to have an interest in this determination.
Dated: May 28, 2019.
Gregory Nephin,
Regional Administrator, Region 8,
EPA/840-QAR-2017-0427; FRL-9994-29-
OAR.
BILLING CODE 6050-80-P

ENVIRONMENTAL PROTECTION AGENCY EPA-HQ-OAR-2017-0427; FRL-9994-29-OAR

RIN 2060-AT73 National Emission Standards for Hazardous Air Pollutants for Asbestos: Notice of Final Approval for an Alternative Work Practice Standard for Asbestos Cement Pipe Replacement

AGENCY: Environmental Protection Agency (EPA).
ACTION: Notice; final approval.

SUMMARY: This document announces our approval of an alternative work practice (AWP) under the Clean Air Act (CAA) in response to a request to use new technology and work practices developed for removal and replacement of asbestos cement (AC) pipe, which is

3534, WJC West Building, 1301 Constitution Avenue NW, Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Eastern Standard Time, Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566-1744, and the telephone number for the EPA Docket Center is (202) 566-1742.

FOR FURTHER INFORMATION CONTACT: For questions about this final action, contact Mr. Kevin Smith, Sector Policies and Programs Division (2043-04), Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711; telephone number: (919) 541-2410; fax number: (919) 541-4991; and email address: kevin.smith@epa.gov. For questions about the applicability of this action, contact Mr. John Cox, Office of Enforcement and Compliance Assurance, U.S. Environmental Protection Agency, WJC South Building, 1200 Pennsylvania Avenue NW, Washington, DC 20460; telephone number: (202) 964-1395; and email address: cox.john@epa.gov.

SUPPLEMENTARY INFORMATION: Acronyms and abbreviations. We use multiple acronyms and terms in this document. While this list may not be exhaustive, to ease the reading of this document and for reference purposes, the following terms and

best retaining material
cement pipe replacement
containing waste material
determination
Society for Testing and
the University
work practice
the Regulations
new pipe
source pipe slurrification



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CTPS

➤➤ **2019** Alternative Work Practice Issued

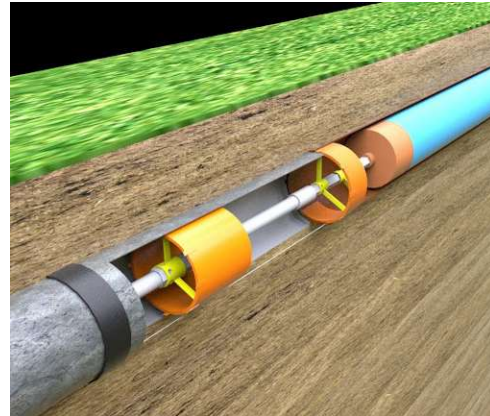
➤➤ **2022** EPA Memo

➤➤ **2023** ASTM Standard for CTPS



CTPS TECHNICAL ENVELOPE

| | |
|------------------------|----------------------------------|
| Diameter Range | 4" - 20" |
| Upsizing | Yes |
| Host Pipe Material | Asbestos Cement (AC) |
| Application Types | Potable Water & Sewer Force Main |
| Typical Install Length | 500+ LF |
| Installation Standard | ASTM F3632-23 |
| Pressure Rating | Per AWWA Standards |



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Carbon Fiber Reinforced Polymer (CFRP)



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CFRP

- For 30-inch diameter and above
 - Requires manned entry
- Polymer applied and cured to host pipe
- Applied like wall paper in sheets
- Mainly used in large diameter concrete pipelines
- Reinforces structural stability of host pipe
 - Class IV fully-structural rehab
- Very expensive



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Putting It All Together...



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Example #1

Criteria:

- 14" and 16" steel water transmission main (no services)
- Existing headloss/pumping issues
- Installed in 1960s (poor as-builts)
- Numerous past failures
- Pressures between 150 and 300 psi
- Mostly 3 ft of cover
- Along a bike path, numerous bends/fittings
- Wanting 50-yr design life



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Example #1

| Method | Applicable? | Reason | Action Items |
|---------------|-------------|--------|--------------|
| SIPP | | | |
| FFRP | | | |
| CIPP | | | |
| Sliplining | | | |
| Pipe Bursting | | | |
| CTPS | | | |
| MICP | | | |
| CFRP | | | |



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Example #2

Criteria:

- 6" cast iron water distribution main (w/ services)
- Min agency standard is 8" for fire flow
- Good as-builts (can locate all bends/valves/etc.)
- Replaced for age; not many failures
- Pressure = approx. 60 psi
- Mostly 3 ft of cover
- Residential neighborhood
- Wanting 50-yr design life



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Example #2

| Method | Applicable? | Reason | Action Items |
|---------------|-------------|--------|--------------|
| SIPP | | | |
| FFRP | | | |
| CIPP | | | |
| Sliplining | | | |
| Pipe Bursting | | | |
| CTPS | | | |
| MICP | | | |
| CFRP | | | |



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Example #3

Criteria:

- 48" steel water transmission main (no services)
- No capacity issues
- Aged, critical pipeline; high consequence of failure
- 50% of pipe wall left
- Pressures above 250 psi
- 6 ft of cover; little to no bends
- Beneath a high-volume roadway
- Wanting 50-yr design life



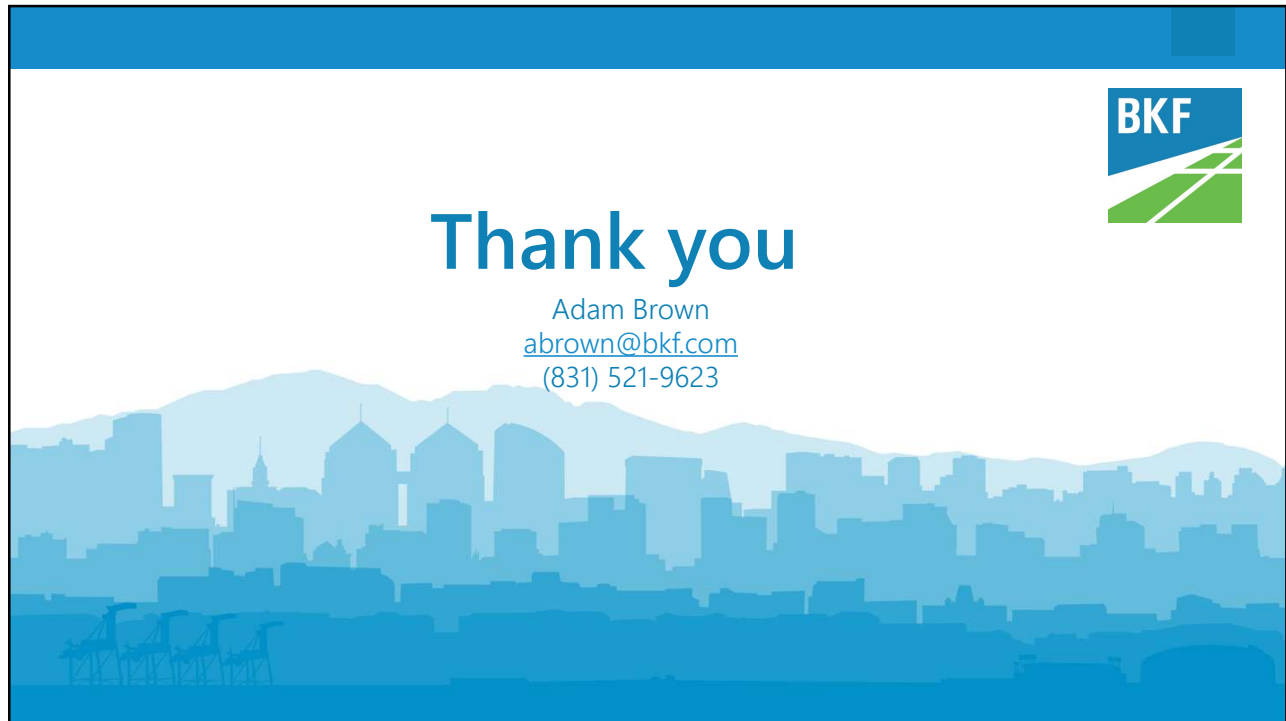
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Example #3

| Method | Applicable? | Reason | Action Items |
|---------------|-------------|--------|--------------|
| SIPP | | | |
| FFRP | | | |
| CIPP | | | |
| Sliplining | | | |
| Pipe Bursting | | | |
| CTPS | | | |
| MICP | | | |
| CFRP | | | |



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